EFFECT OF DIFFERENT FOODS ON THE LARVAL AND POST-LARVAL DEVELOPMENT OF THE MOTH *PRODENIA LITURA* Fb. (LEPIDOPTERA, NOCTUIDAE)

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(*With two graphs*).

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Introduction.

The larva of the moth *Prodenia litura* Fb. (Noctuidae, Lepidoptera) is an important pest of cauliflower in Bengal; it is called *kafipoka*, the cauliflower worm, by the peasantry. In the Tamil areas of the Madras Presidency the larva is known as *arakkan*. The depredation of the larva is not confined to any particular crop but extends over a number of economic plants and fruits in India as well as other parts of the world. In Egypt the larva is a great pest of cotton, and is known as the cotton-worm; in Nyassaland, the larva chiefly injures tobacco, and is popularly called the tobacco-caterpillar; in Rhodesia, it is known as the tomato-caterpillar; in Mauritius as the bean-enemy-worm.

The moth *P. litura* has been the subject of investigation by a number of authors: Wilcock (1905) furnished a list of hosts devastated by this caterpillar. Fletcher (1914) gave a short account of its bionomics, and published a list of plants which might be injured by the species. Janish (1930) made experiments on this moth under different temperatures and humidities. Bishara (1934) gave an elaborate account of the general morphology and bionomics of this species and also added a list of plants, fruits and flowers which are injured by the larva of *P. litura*.

From the list furnished by the previous authors it is seen that the larva of *P. litura* can grow on fifty-four different types of vegetable food-stuffs. So, a knowledge of other plants which are likely to harbour this pest, will be useful in checking the spread of its infestation from one plantation to another. I have endeavoured, therefore, in this paper to furnish a fresh list of hosts which are subjected to attack by *P. litura*. Further, since the pests have a wide range of host plants, it is important to know how far the duration of the life cycle as well as the size of the insect are influenced by the various food-stuffs, other factors such as temperature and humidity being kept constant.

The present problem was, therefore, undertaken with a view (1) to supply an additional list of hosts which can be infected by the larva of *P. litura*, and (2) to report variations in larval growth and period, pupal size and period, and the size of the adult caused by varying the food-stuffs. The feeding experiments were carried under room conditions during the winter months as well as under a constant high temperature of 30°C in an insectary fitted with a temperature-control apparatus. The main food-stuffs used in the experiments were cauliflower, green banana fruit, mulberry leaf, fresh cabbage, green papaya fruit, lettuce leaf, and the leaf of the silk-cotton tree.

Acknowledgments.

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Experimental.

1. *Materials.*

The specimens used in these experiments were reared in the laboratory. They were first obtained in the larval stages from an infected field at Ballygunge Park. They were also collected from Dhapa, situated on the outskirts of Calcutta. A few were obtained from cauliflowers sold in the market.

2. *Methods.*

For raising the stock, the moths were reared in the laboratory for several generations, the larvae being fed with cauliflower. Round glass jars measuring 4 inches in diameter and 6 inches in depth were used for all the experiments. The mouth of the jar was tied with muslin. Each jar was thoroughly cleansed and washed with sodium carbonate solution followed by lysol lotion.

To make a correct operation in the performance of the experiment, special precaution was taken against any chance of sudden shortage of food by providing each jar with large quantities of fresh leaves picked from the gardens, also with chips of the same. Evans (1938) noted that the larvae of *Pieris brassicae*, fed on cabbage leaves which were grown under bad conditions of light, behave differently from those fed on leaves grown under natural conditions of light, and Wigglesworth reported (1939) that increase of temperature stimulates metabolism leading to food shortage and death. At the initial stage of the experiments the food-stuff in each jar was changed twice till the advanced stage of the larva, when the change was made thrice daily.

Since this species pupates under earth a little below the soil surface as reported by Fletcher (1914) and Bishara (1934), saw-dust was put at the bottom of all the experimental glass jars for pupa-formation under artificial condition.

In the experiment No. 1, twenty kinds of vegetable food-stuffs were tried. Sixteen of these which are not star marked (vide list D) were found growing in close proximity to the plantation infested by the pest. For drawing this fresh list (vide list D) of plants subjected to the attack of *P. litura* larvae, with the exception of the star marked foods namely radish, apple, nashpati and papaya (where roots and fruits were fed) in all the cases, experiments were made with the leaves of the listed host plants. To economise the glass jars and check the results, the experiments were arranged in three sets, with seven glass jars in each set. A number of twenty larvae of *P. litura* were kept in each jar. The larvae were kept under observation until the pupal stage.

In experiment No. 2 the larvae were fed with the eight kinds of food-stuffs such as cauliflower, green banana fruit, mulberry leaf, lettuce leaf, cotton leaf, palam leaf, green papaya fruit and cabbage; and then the variations, in the size of the larva with their ages, pupal size and adult size were recorded. And also the durations of the larval period and pupal period were noted. These observations are given in different tables (Tables I—VII) and the rates of the different larval growths have been represented by Graphs A & B.

To conduct the experiment No. 2 under room conditions, twenty-four glass jars were employed. The jars were put in three different sets, each set containing eight jars. Food of one type was contained in three jars, one in each set, and eight kinds of food-stuffs were altogether tried. The object of having three sets is to ensure the continuation of experiments, if accidentally specimens in any one set die for one reason or other. As it was observed that if more specimens are kept in the limited space of a single jar, overcrowding occurs and they do not thrive well; hence in each of these jars ten freshly emerged larvae of the same parents were kept. The variations observed in these sets are given in tables. For comparison of the different larval sizes, they were measured at an interval of five days, till the larva attained the prepupal stage. Further, for recording the pupal duration, as soon as the pupae were formed in the eight respective foods, they were transferred in different jars, but having identical environmental conditions, and the time at which the imago emerged was correctly noted. This gave the duration of the pupal life.

To conduct the experiment No. 2 under high temperature the same method was followed, but with the difference that in this experimentation the larvae were measured at intervals of four days instead of five, since the rate of the larval growth was accelerated due to the rise of the temperature. The results have been tabulated in different tables.

For the different tables, the linear growth of the larvae and the size of the pupae and imagoes were measured by an ordinary scale. But in case of the newly emerged larvae which were too small to be measured by a scale, they were measured by stage micrometer. The different measurements shown in tables are the average of ten readings. The full length of a larva and pupa means distance from tip to tip and the breadth shows the maximum width of the fourth abdominal segment. In references to the procedures provided by Lefroy and Howlett (1909) and Fletcher (1914), the body length and the abdominal size at the greatest diameter of the imago were recorded. And the expansion of the wings (fore and hind) was measured from the distal end of the one side of the wing (fore and hind) to the distal end of the other side of the wing (fore and hind). The distal width of the individual fore and hind wings was noted from the greatest distal area of each wing. To have a single standard of measurement, the fore wing was measured along the subterminal line as referred by Torre-Bueno (1937); and the hind wing was measured from the greatest width at the posterior terminal area of the hind wing.

3. *Observations.*

To the list of vegetables and plants, damaged by *P. litura*, reported by previous authors (shown here in columns A, B, C)—twenty more are added by the present author and these are shown in column D. The fact that this insect also attacks such fruits as apple, papaya, etc. shows the wide range of host plants.

List of hosts.

The following is the list of vegetables, foliages, fruits, etc. damaged by the moth *Prodenia litura.*

WILCOCK'S LIST
(A)

1. Cotton.
2. Bersin (Egyptian clover).
3. Lucerne.
4. Maize.
5. Pea-nut.
6. Beet.
7. Sweet potato.
8. Colocasia.
9. Potato.
10. Leaf beet.
11. Mallow.
12. Jew's mallow.
13. Spinach.
14. French bean.
15. Leamia (*Hibiscus esculentus*).
16. Til (*H. cannabinus*).
17. Red pepper.
18. Tomato.
19. Grape vine.
20. Sweet orange.
21. Plum.
22. Mulberry.
23. Crysanthemum.
24. Castor.

BISHARA'S LIST
(B)

1. Wheat.
2. Rice.
3. Bledi beans.
4. Soya beans.
5. Fenugreek.
6. Egg-plant.
7. Water melon.
8. Cucurbit.
9. Cabbage.
10. Onion.
11. Mandarines.
12. Guava.
13. Fig.
14. Poplar.
15. Banana.
16. Rose.
17. Mint.
18. Viola.

FLETCHER'S LIST
(C)

1. Castor.
2. Tobacco
3. Maize.
4. Tomato.
5. Colocasia.
6. Agathi.
7. Jute.
8. Indigo.
9. Lucerne.
10. Brinjal.
11. Cabbage.
12. Elephant yam
13. Pea.
14. Plantain.
15. Grass.

WRITER'S LIST OF ADDITIONAL FOOD-STUFFS.

(D)

1. Jamrul (*Eugenia malaccensis*, Lin.).
2. Karamcha (*Carissa carandas*, Lin.).
3. Jack tree (*Artocarpus integrifolia*, Lin.).
4. Sajna (*Moringa pterygosperma*, Gaertn.).
5. Aswatha (*Ficus religiosa*, Lin.).
6. Lettuce (*Lactuca scariola*, Lin.).
7. Celery (*Apium graveolens*, Lin.).
8. Cauliflower (*Brassica oleracea*, Lin.).
9. Shaddock (*Citrus medica*, Lin.).
10. Palam (*Spinacia oleracea*, Lin.).
*11. Radish (*Raphanus sativus*, Lin.)
*12. Apple (*Pyrus malus*, Lindl.).
*13. Nashpati (*Pyrus sinensis*, Lindl.).
14. Aparajita (*Clitoria ternatea*, Lin.).
15. Hasna-hena (*Cestrum nocturnum*, Lin.).
16. Thusa (*Thuya orientalis*, Lin.).
17. Ata (*Anona squamosa*, Lin).
*18. Papaya (*Carica papaya*, Lin.).
19. Mango tree (*Mangifera indica*, Lin.).
20. Ashshaeorah (*Glycosmis pentaphylla*, Corr.).

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* Are root and fruits,

TABLE I

Effect of different foods on the larval growth of *P. litura*, reared under room conditions (average temp. 19·5°C): the sizes were recorded at *intervals of five days*

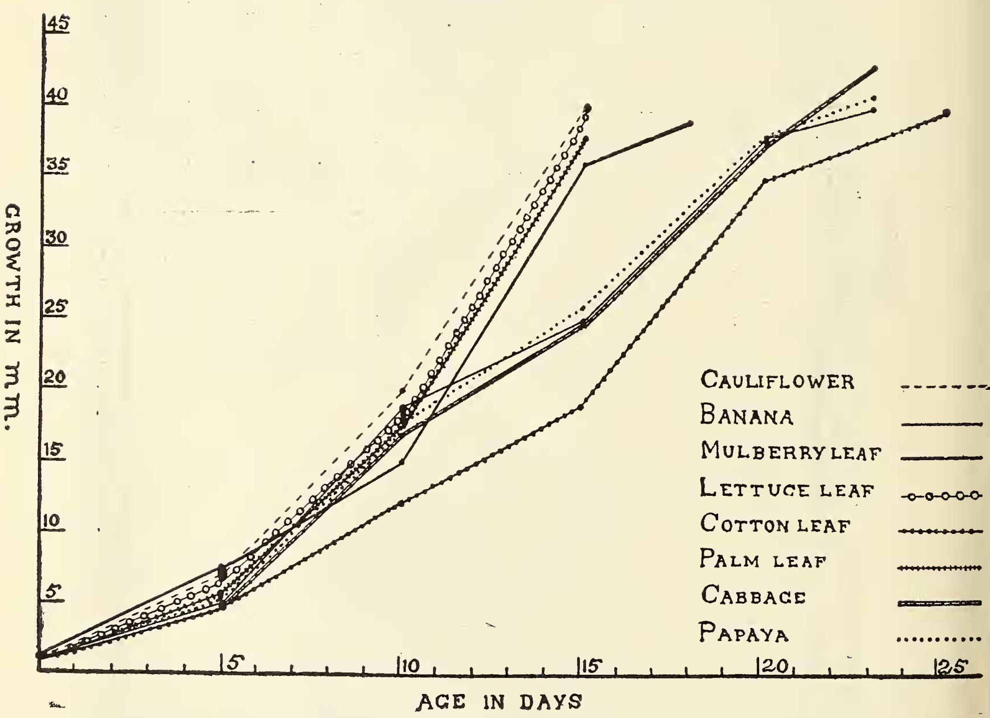
Food	Size of freshly emerged larva	Sizes of the larva in mm. after—				
		5 days	10 days	15 days	20 days	25 days
Cauliflower		7·00 × 1·1	20·30 × 3·6	39·60 × 6·6	—	—
Banana fruit (green)		4·60 × 1·0	19·00 × 3·0	25·00 × 4·1	37·60 × 5·3	*40·30 × 6·3
Mulberry leaf		7·00 × 1·0	15·30 × 3·0	36·00 × 5·0	*38·65 × 5·9	—
Lettuce leaf	1·06 × ·22 mm.	7·30 × 1·0	19·00 × 3·3	40·30 × 6·3	—	—
Cotton leaf		5·30 × 1·0	12·00 × 2·0	19·30 × 3·6	35·00 × 5·0	40·31 × 5·3
Palam leaf...		6·60 × 1·0	18·60 × 3·3	38·30 × 5·6	—	
Cabbage		5·70 × 1·0	18·00 × 3·0	25·00 × 4·0	37·60 × 5·3	*43·30 × 6·3
Papaya fruit (green)		5·86 × 1·2	19·25 × 3·5	26·35 × 4·6	38·45 × 5·1	41·45 × 5·9

* after 3 days, because the larvae reached the prepupal stage earlier. — Specimen pupated.

The effect of different food-stuffs in inducing variation in the larval sizes, under room conditions are shown in table I. It may be seen from the table that while the variation on the 5th day of observation is negligibly small, that on the 10th day is large; further variations become appreciably large in the case of cauliflower and cotton leaf. On the 15th day, the increase is noticeable in four examples—cauliflower, mulberry leaf, lettuce leaf and palam leaf. These sizes are distinctly larger than with banana fruit, cabbage and papaya fruit. Further it is worth noting that the largest larval size is attained in case of cabbage, while papaya comes next. The sizes reached by the larvae when fed respectively on banana, lettuce and cotton are more or less equal. The smallest larval size is found with mulberry and the palam. The cauliflower as diet occupies an intermediate place so far as its effect on size is concerned.

The rate of larval growth is shown in graph A. It may be noted that the rates of the larval growth as fed on different foods are practically identical for the first five days. Differences become observable onwards from five to ten days. During these periods the growth in case of cauliflower is highest, while it is smallest in the case of cotton. Further it is seen that the lines in the graph representing the larval growths for cauliflower, mulberry, lettuce and palam bifurcate at the 10th to 15th as these slope up. On the other hand the

GRAPH A



Graph A, showing the variations in the rate of the larval growth, in *P. litura*, when reared under room conditions (average temp. 19.5°C) on various foods. The growth means linear size.

rates of growth at this period with papaya, banana and cabbage are comparatively small; hence they shift downwards as shown by the growth lines in the graph. The line representing the rate of the larval growth in cotton stands last.

Taple II shows the different sizes attained by the larvae of *P. litura* while kept under high temperature, other conditions being equal. This table shows that the variation in the larval sizes on the 4th, 8th, 12th day, etc.,

TABLE II

Effect of different foods on the larval growth of *P. litura*, reared at a high temperature (30°C) : the sizes were recorded at *intervals of four days*

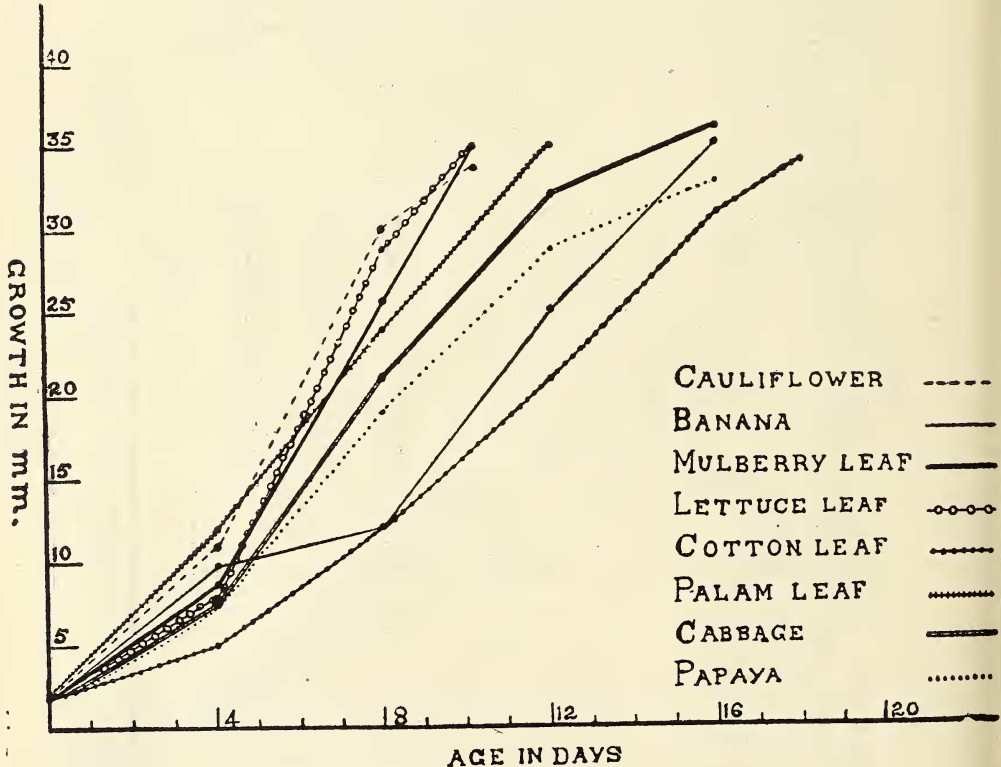
Food	Size of freshly emerged larva	Sizes of the larva in mm. after –				
		4 days	8 days	12 days	16 days	20 days
Cauliflower	1·81 × ·26 mm.	10·75 × 2·5	29·66 × 5·2	*34·16 × 6·0	–	–
Banana fruit (green)		4·71 × 1·1	11·83 × 2·1	25·25 × 4·0	35·20 × 6·4	–
Mulberry leaf		9·33 × 2·0	26·00 × 4·6	*34·91 × 6·0	–	–
Lettuce leaf		8·41 × 2·1	29·20 × 4·9	*34·80 × 6·1	–	–
Cotton leaf		4·81 × 1·0	12·10 × 2·5	21·25 × 3·5	30·66 × 4·6	*34·9 × 5·9
Palam leaf		12·01 × 2·0	24·00 × 4·0	35·33 × 6·0	–	–
Cabbage		8·33 × 2·0	20·51 × 4·0	32·00 × 5·2	36·00 × 6·1	–
Papaya fruit (green)		8·00 × 1·8	19·00 × 3·3	29·40 × 5·5	33·40 × 5·8	=

* after 2 days, because these larvae reached the prepupal stage earlier. — Specimen pupated.

occurs in proportion to their growth sizes under the room condition, only the sizes at the different ages of the larvae reared on palam indicate their rapid growth at high temperature. This table also shows that the larvae maintained on cabbage attain the greatest size as in Table I, but at the final stage, the larval size attained with papaya, banana, lettuce, cotton, cauliflower, palam and mulberry as given in this table (Table II), does not follow the order seen in Table I. It is also found that at the final stage the sizes of the larvae are comparatively smaller than the respective sizes noted under the room condition.

Graph B shows variations in the rates of the growth of larvae, four days old, reared on the different diets. The rate of the larval growth in this period is appreciably greater with palam leaf and cauliflower, and less with banana and cotton. Between the ages of four and eight days, the rates of the larval growth with cauliflower, lettuce and mulberry are more accelerated than

GRAPH B



Graph B, showing the variations in the rates of the larval growth in *P. litura,* when reared in a high temperature (at 30°C) on various foods. The growth means linear size.

in other cases. The graph in general coincides with the previous graph but the lines representing the rates of growth are more straight, specially the ones representing the rate of the larval growth with cauliflower, lettuce, mulberry and palam which slope rapidly up as compared with cabbage, papaya, banana and cotton. The growth with cotton shows periodicity.

Table III shows the durations of the larval stadium as observed under the room condition and under the high temperature. In the experiment under room condition, the duration of the larval period with cauliflower is the shortest, while with cotton it is relatively prolonged. Results under high temperature too follow this order. Here also the margin between the larval durations

TABLE III

Effect of different foods on duration of larval life of *P. litura*, under the room condition (average temp. 19·5°C) and in a high temperature (30°C) experiments.

Food	Larval duration in days, under	
	Room condition (19·5°C)	High temperature (30°C)
Cauliflower ...	18	11
Banana fruit (green) ...	26	17–19
Mulberry leaf ...	20–21	12
Lettuce leaf ...	18–19	12
Cotton leaf ...	27–28	19–20
Palam leaf	19–20	12
Cabbage	25	17
Papaya fruit (green) ...	26	17

respectively experimented with cauliflower and cotton is very broad. It may be pointed out that as the effect of high temperature the duration of the larval period is shortened on an average by 7-8 days.

Table IV shows the variations in the sizes of the different pupae as observed under room condition and in a high temperature experiments. In the experiment under room condition, the largest pupal size is obtained with larvae fed on cauliflower and next in order come lettuce, palam and mulberry.

TABLE IV

Effect of different foods on the pupal sizes of *P. litura*, under room condition (average temp. 19·5°C) and in a high temperature (30°C) experiments.

Food	Sizes of the pupae in mm. under	
	Room condition (19·5°C)	High temperature (30°C)
Cauliflower ...	19–22 × 7–8	18–19 × 6–7
Banana fruit (green) ...	17–18 × 5–6	16–17 × 5
Mulberry leaf ...	19–20 × 6–7	18–19 × 6
Lettuce leaf ...	20–21 × 6–7	18–19 × 6
Cotton leaf	14–16 × 4–5	15 × 5
Palam leaf	19–21 × 6–7	18–19 × 6
Cabbage	19–20 × 5–6	17–18 × 5–6
Papaya fruit (green) ...	19–20 × 5–6	17–18 × 5-6

The sizes of the pupae experimented with cabbage and papaya are equal, but they are larger than with banana, the smallest pupal size being with cotton. Pupae

TABLE V

Effect of different foods on the duration of pupal life in *P. litura*, under room condition (average temp. 22·2°C) and in a high temperature (30°C) experiments.

Food	Pupal duration in days, under	
	Room condition (22·2°C)	High temperature (30°C)
Cauliflower ...	9	6–7
Banana fruit (green) ...	11	9
Mulberry leaf ...	10	8
Lettuce leaf ...	9	7-8
Cotton leaf ...	12	10
Palam leaf	9	7
Cabbage	11	8–9
Papaya fruit (green) ...	11	8–9

reared under high temperature, but with identical food-stuffs, show a general reduction in their sizes as compared to those under the room condition.

Table V shows the durations of the pupal period as observed under both the experimental conditions. This table reveals that the durations of the

TABLE VI

Effect of different foods on the sizes of the moth, in *P. litura*, when reared in a room condition (average temp. 19°–22°C).

Food	Body length	Abd. width	Fore wing		Hind wing	
			Expanse	Distal width	Expanse	Distal width
	mm.	mm.	mm.	mm.	mm.	mm.
Cauliflower ...	19–22	6–7	38–40	8–9	30–32	11
Banana fruit (green).	17–18	4–5	34–36	7–8	26–28	8–9
Mulberry leaf ...	19–20	5–6	36–38	8-9	28–30	10–11
Lettuce ...	20–21	5–6	40	9	30–32	10–11
Cotton leaf ..	14–16	3–4	32–34	7–8	24–26	8
Palam leaf ...	19–21	5–6	38–40	9	30–32	11
Cabbage ...	19–21	4–5	34–36	7–8	26–28	8–9
Papaya fruit ...	19–20	4–5	34–36	8	26–28	8–9

pupal life is slightly variable. Under room conditions the duration if pupal life is shortest with cauliflower, lettuce and palam. The mulberry leaf stands next in order. The pupal durations with banana, cabbage and papaya slightly exceed these and are more prolonged with cotton. The results observed in the high temperature experiment also indicate that the shortest duration occurs with cauliflower, palam, mulberry and lettuce. The durations of pupal life with cabbage, papaya and banana are practically the same; with cotton however it is maximum.

Table VI shows the variations in the sizes of the different moths as observed under the room condition. This table shows, that under such condition, the largest size of the moth is obtainable if reared on cauliflower, mulberry, lettuce and palam. The next sizes are obtained with banana, cabbage and papaya; while those reared on cotton are the smallest in size.

Table VII shows the variations in the sizes of the different moths, observed under the high temperature, other conditions being the same as before. The size of the different moths stands in the same order as in the previous table. Further it is seen that in the high temperature condition the sizes of the different moths are smaller as compared to those bred under the ordinary room condition.

TABLE VII

Effect of different foods on the sizes of the moth, in *P. litura*, when reared in a high temperature (30°C).

Food	Body length	Abd. width	Fore wing		Hind wing	
			Expanse	Distal width	Expanse	Distal width
	mm.	mm.	mm.	mm.	mm.	mm.
Cauliflower ...	18–19	5–6	36–38	8	26–28	10
Banana fruit (green).	16–17	4–5	32–34	8	24–26	9
Mulberry leaf ...	18–19	5–6	34–36	8	26–28	10
Lettuce leaf ...	18–19	5–6	36–38	8	26–28	10
Cotton leaf ...	14–15	4	30–32	7	24	8
Palam leaf ...	18–19	5–6	36–38	8	26–28	10
Cabbage ...	17–18	5	34–36	8	24–26	9
Papaya fruit (green).	17–18	5	34–36	8	24–26	9

Finally with regard to time for completing the life cycle, i.e., the period from the hatching of larvae to the emergence of imago, under the room conditions, was 27 days with cauliflower, 37 days with banana and papaya, 31 days with mulberry, 28 days with lettuce, 40 days with cotton, 29 days with palam, 35 days with cabbage; while in the high temperature the period covered 18 days with cauliflower, 28 days with banana, 20 days with mulberry and lettuce, 30 days with cotton, 19 days with palam, 26 days with cabbage and 29 days with papaya. It is interesting to note that by comparison with the temperature of room conditions the heat factor has uniformly reduced the duration on an average by 9-10 days.

Discussion.

Certain species of lepidoptera can live on different varieties of food-stuffs, while others thrive only on some specific plants. The larvae of the moth *P. litura* belong to the first category, according to the information given by

Wilcock (1905), Fletcher (1914), Bishara (1934) and the additional list provided by the present experiments.

To inquire into the influence the various food substances exert on the different stages of development of *P. litura*, experimental feeding under room conditions was arranged during the winter months. But owing to diurnal and seasonal temperature fluctuations, the investigation was also conducted at a constant temperature. Further, as the room condition experiments were performed during the winter season they were practically at low temperatures. It was thought therefore necessary to hold the experiments at a high temperature too. Now as to the effect of temperature on the life of the moth, Janish (1930) found that at 29°-30°C, *P. litura* develops rapidly and reaches its physiological death within the shortest time. He considered this temperature as the optimum temperature. Bishara (1934) however reports that high temperature begins at 28°C. The temperature 30°C was therefore preferred for the high temperature experiments.

From Table I and Graph A, it is seen that the course of the larval development is affected by the different food-stuffs. It is particularly proved between the two sets of the larval sizes on the 15th day, in Table I. Here the larger sizes of the larvae fed on cauliflower, lettuce, mulberry and palam food, are for reaching the last larval stage earlier, due to the rapid growth induced by the respective food-stuffs. Whereas papaya, banana and cabbage made smaller size larvae respectively, by prolonging the larval stages due to the slow growth induced by these food-stuffs. Apparently for these in Graph A, the lines representing the larval rate of growth in the former set of foods, between the ages of ten to fifteen days, move quickly upwards, while the lines showing the larval rate of growth in the latter set of foods in the corresponding period, comparatively shift downwards. These facts suggested therefore that the food ingredients, needed for the larval growth were different in these two sets of food-stuffs. A similar observation was made by Sattler (1939) on the nun moth, *Lymantria monacha*. By feeding the larva with oak, larch and spruce, the larvae showed rapid development. The rate of the larval growth slowed down when fed with beach, apple and pine; while adler prolonged considerably the larval period. Again from the sizes attained by the different larvae at the last stage in Table I, it follows that the food has a very little effect on the final size of the larvae. But the fact, that in case of the food substances such as mulberry leaves, the size dwindled down below the average, shows however that nutrition does affect the final size. But on careful thought the explanation suggest itself that the size is not adversely affected, because, all the different food substances may contain the same essential ingredients needed for the final size, while the size is affected where these essentials are lacking in the food-stuffs.

From Table II, it is seen that the high temperature in different food-stuffs, causes appreciable variations at the age of 4, 8, etc. days. The marked variations in size of the 4th and 8th day, as compared to results obtained in the experiment, conducted at room temperature are evidently due to acceleration of growth induced by high temperature. This is why in Graph B, the lines representing the different rates of larval growth are straight in comparison with those in Graph A. As it is known that heat within the vital limit increases the rate of all metabolic processes, and in the developmental stages, the extra energy is expended on growth which is correspondingly accelerated (Uvarov 1931, Wigglesworth 1939), the slight irregularities in the position of the larval last stage sizes, in the different food-stuffs in this table, in comparison to Table I, suggest that in the high temperature experiment the developing larvae did not utilise the respective food reserves satisfactorily for the rapid larval growth, due to the rise of temperature. Moreover in general the reduction of the larval sizes in Table II, in comparison to Table I, is explained by the fact that, decidedly in low temperature, the percentages of food absorbed and utilised by the different larvae for building up the tissues, are greater than those at the high temperature. These are not only theoretical considerations, but facts proved exactly by Uvarov (1931) from the results of various authors.

From Table III it is proved that the duration of the larval period undergoes variations, and this is entirely dependent on the type of food the larva utilises during its larval period. The quick growth of the larvae with cauliflower accelerated the usual rate of growth in *P. litura*, and consequently the larval duration was shortened; and similarly the reverse effect occurred in the fate of the larvae fed on the cotton leaves and apparently their larval period is prolonged. Further the general shortening of the larval periods at the high temperature is accounted for since the food-stuffs remained constant in both the experiments. Uvarov (1931) has forwarded a considerable number of experimental results from different authors. According to him Standfuss (1896) recorded that, by the application of a high temperature, the larval period of *Lasiotampa quercifolia* L. can be shortened from the normal 22-26 to 7-12 weeks.

From Table IV it is seen that the size of the pupae is affected by the different foods. The pupal sizes in *P. litura* are therefore solely dependent on the nutritive effect of the individual food. In view of this table it is proved that cauliflower stands first, next lettuce, palam, and mulberry; cabbage and papaya are equal, but richer than banana; and cotton is very poor. Further it is seen from the table that the high temperature in general reduces the sizes of the different pupae from the different foods, in comparison with their respective sizes noted in the room condition. Again from both the results recorded, it is interesting to note that the largest size larva is not the producer of the greatest size pupa.

From Table V it is seen that the food-stuffs cauliflower, lettuce, palam and mulberry have got the greatest food values for the shortening of the pupal period; the food values are ordinary for banana, cabbage and papaya, and very poor in the case of cotton leaves. Further it is seen in this table that there is a general reduction of the pupal period in the high temperature obviously due to the rise of the experimental temperature, since the food-stuffs remained constant in both the experiments.

From Table VI it is proved that the size of the moth depends on the type of nutrition during its larval period. In view of the present results it is evident that the best nutrition in *P. litura* is derived from cauliflower, lettuce, palam and mulberry, and then from banana, cabbage and papaya. It is worth mentioning that cauliflower has produced the greatest body length and abdominal breadth of the moth. Further, the expansion of the fore wings and the hind wings are greatest in the moths with cauliflower, lettuce and palam, but they are comparatively smaller with mulberry. Regarding the greatest distal width of an individual fore wing and hind wing, it is marked that the variations are like the variations in the body length, abdominal breadth and expansions of the wings. Also it is worth noting the fact that the greatest size larvae do not produce the greatest size moths, as in Table I the greatest sizes are found associated with cabbage, but here (Table VI) with cauliflower. A similar observation has been made by Alpatov (1929) in his thyroid gland feeding experiment with *Drosophila melanogaster* Mg. He found that the larvae in the hog muscle and thyroid are larger than the larvae in the hog muscle and yeast, but finally observed that the imagos of the former are smaller than those of the latter.

From Table VII it is proved that in the high temperature, the sizes of the different moths become more reduced than their respective sizes noted in the room condition (Table VI) with the respective food-stuffs. As foods remained constant in both the experimentations, this is certainly due to the heat effect. While high temperature has a certain effect on the larva and pupa in their sizes and durations, now it is seen that it affects also the sizes of the moths. A brief review of similar results has been forwarded by Uvarov (1931). According to Uvarov, Titschak (1925-27) in his experiments on the clothes moth, *Tinola bisellella* Hum., demonstrated that at lower temperatures, larger and heavier moths are produced. Similar conclusions as to lower temperatures producing insects of larger size have been reached by a number of other investigators, e.g., Alpatov and Pearl (1929) with *Drosophila melanogaster* Mg., by Schlottke (1926) in the case of *Habrobracon juglandis* Say., by Musconi (1924) with *Calliphora erythrocephala* Mg., by Dewitz (1913) with *Porthelria dispar* L., and by Standfuss (1896) with various species of lepidoptera.

Now in ending the discussion it is well to mention that, since it is proved that the larval growth, larval duration, pupal size, pupal duration and the size of the moth in *P. litura* are entirely dependent on the qualities of the food it utilises during its larval period it would be unwise to criticise or evaluate the results forwarded by the previous authors such as Fletcher (1914), Janish (1930) and Bishara (1934).

Summary.

1. Experiments were conducted for observing the infestation of the *P. litura* larva; it was noted that the larval food selection was very plastic, including leaves, fruits and roots.

2. Experiments were also arranged to observe the effect of eight different foods upon the life of *P. litura* under the room condition in the winter months and in a high temperature at 30°C.

It was found that under the ordinary room condition and in the high temperature (30°C.) experiments, when the larvae of *P. litura* were fed with eight different selected foods, they underwent variations in the larval growth, larval period, pupal size, pupal period and the size of the moths. When fed with cauliflower, mulberry, lettuce and palam the larval growths were most rapid, the larval durations shorter, the pupal sizes largest, the pupal durations hastened, and larger size moths were produced; when fed on banana, cabbage and papaya, the larval growths were ordinary, larval durations prolonged, pupal size medium, pupal durations lingered and medium size moths were obtained; when fed on cotton leaves, the condition of the larval growth was very poor, larval duration much delayed, pupal size very small, pupal duration comparatively prolonged, and very small size moths were produced.

It was also proved that there was a comparatively rapid larval growth, shorter larval duration, smaller pupal size, faster pupal duration and a smaller size moth in the high temperature experiment.

Conclusion.

The larvae of *P. litura* can devastate seventy-four types of different foodstuffs.

The larval growth and duration, the pupal size and duration, and the size of the moth in *P. litura* are dependent on the type of the food the larva utilises during its larval period.

Quick growth shortens the life cycle and the processes are more hastened in the high temperature.

Decidedly low temperature produces bigger size larva, pupa and imago, and the high temperature has an adverse effect on the different sizes.

The largest size larva in *P. litura* is not the producer of the biggest size pupa and moth, but the latter are solely due to the type of ingredients contained in the food utilised by the larva.

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